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MINIMIZING THE EFFECTS OF INSECTICIDES ON MONTANA'S TERRESTRIAL WILDLIFE, WITH SPECIAL REFERENCE TO GAME BIRDS[1]

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The purpose of this paper is to create an awareness of the many different effects of insecticides on Montana's wildlife and to recommend procedures which should minimize the harmful effects. Except for individual references, this paper *is not* intended to be a "cookbook" for solving Montana insecticide-wildlife problems. Factors which preclude the preparation, much less the existence, of such a book include:

1. The variety and complexity of Montana's ecosystems, her wildlife and her people; Montana is coinhabited by 105 species of mammals (Wright, 1959), other than humans, 330 species of birds (286 are resident species) (Davis, 1963), and an unknown number of insect species, most of which have no adverse economic effects.
2. The current registration of 32,000 pesticides with the U. S. Environmental Protection Agency (Smith, C. L., personal communication).

A History of Concern

The earliest Montana insecticide-wildlife study involved the effects of chlordane bait and aldrin spray, used for grasshopper control, on bird populations in Powder River County (Eng, 1952). Excessive DDT levels in forest grouse and big game were documented in the early 1960's in southwestern

[1]Presented at Pesticides Usage, Safety, and Public Health Seminar, March 28, 1973, University of Montana Biological Station, Yellow Bay, Flathead Lake, Montana.

Montana (Pillmore and Finley, 1963; Mussehl and Finley, 1967). Termination of DDT use in spruce budworm control programs on Montana National Forest lands in 1963 led to a study of the effects of alternative insecticides, dibrom and zectran, on budworm and grouse populations (Mussehl and Schladweiler, 1969). During the summer of 1964, the effects of dieldrin and malathion on sharp-tailed grouse were investigated in northcentral Montana (McEwen and Brown, 1966). The response of juvenile raptors to DDT in their diets was studied in the mid-1960's (Seidensticker, 1968). Population fluctuations of osprey, with special reference to the effects of DDT, in the Flathead Lake area were studied during 1966-70 (MacCarter, D. L., 1972; MacCarter, D. S., 1972).

Results of these and other studies across the nation confirm the legitimate concern for the effects, many of them detrimental, of insecticides on wildlife by the Montana Fish and Game Commission. Their concern, however, only reflects that of almost a quarter of a million Montana resident hunters and fishermen, 40,000 ranchers and farmers, plus hundreds of thousands of resident and non-resident campers, photographers, sightseers and other recreationists.

People want wildlife and they want it in the largest possible numbers.

Land ownership in Montana is approximately 65 percent private, 30 percent federal, and 5 percent state (Public Land Law Review Commission, 1970 *In* Mussehl and Howell, 1971:3). Only 0.2 percent of Montana's land is directly managed (owned or leased) by the Montana Fish and Game Department (Mussehl and Howell, 1971:31). It is obvious that much of the wildlife people want is produced, viewed and pursued on private land.

The Montana Fish and Game Commission has been instrumental in guiding pesticide-use policy on federal lands within Montana; there has been some guidanc

on state lands also. The Commission has offered professional assistance to private landowners in pesticide-use decisions; unfortunately, for a significant part of Montana's wildlife, this assistance has not been utilized. A copy of the Commissions' Policy on Pesticides is appended to this report (Appendix I).

INSECTICIDE-WILDLIFE PROBLEMS

Effects of insecticides on wildlife span the entire scope from high toxicity resulting in sometimes dramatic direct mortality to low toxicity with no noticeable mortality. Evaluation of any insecticide should consider avenues in which effects of the compound are manifested in wildlife. These frequently refer to penned animal experiments which are necessary because: they provide facilities for determining lethal levels and side effects of a single compound on a given species; species in the wild are frequently difficult to obtain during insecticide-use seasons; and, controlled diets prior to insecticide testing minimize confusion with background levels of insecticides previously contacted by the wildlife.

Field test results are highly desirable references; their availability depends on governmental funding and advanced planning. The combined use of experimental pen and field tests provides the most reliable and meaningful insecticide-wildlife evaluations.

Acute vs. Chronic Toxicities

Most wildlife is secretive during summer midday hours. Individuals may or may not receive direct exposure during insecticide application. Early morning and evening activity periods, however, result in a minimal twice-daily contact with sprayed vegetation and, in the case of birds, insects. The distinction between acute and chronic exposure must therefore be made.

Acute toxicity refers to immediate effects on an animal of a single exposure to an insecticide; the time lapse is usually limited to a few hours or days following insecticide exposure. Chronic toxicity refers to long term effects (which may or may not be severe) following multiple dosage or exposure; time lapse here implies several weeks to several months (adapted from Rudd and Genelly, 1956:203).

To illustrate these differences, the acute toxicity of chlordane for pheasants is about 500 mg/kg (Rudd and Genelly, 1956:60). Diets containing 500 ppm chlordane resulted in 50 percent chick mortality in less than 10 days (De Witt et al., 1963); average chlordane consumption at LD_{50} was 550 mg/kg. Chronic exposure to a sublethal (50 ppm) chlordane diet caused 50 percent chick mortality in less than 100 days. The average chlordane consumption per chick at LD_{50} was only 170 mg/kg. Adult pheasants fed a 200 ppm chlordane diet attained LD_{50} in less than 100 days; they had eaten an average 340 mg/kg chlordane.

Acute or Direct Toxicity

A given insecticide exhibits varied acute toxicities in different wildlife species (Table 1). Thus mourning doves are over six times as sensitive to 99 percent technical Baytex as pheasants. Fifty percent of mallards may be expected to die after an average acute dose of 5.94 mg/kg 90 percent technical Baytex; chukar mortality levels also reflect the 90 percent technical formulation. Baytex appears to be highly toxic to all seven species listed, but of the seven, chukars stand the least chance of Baytex exposure due to the improbability of its application on xeric chukar ranges.

Table 1. VARIATION IN LETHAL LEVELS OF BAYTEX FOR SEVEN SPECIES OF BIRDS.[1]

SPECIES	MEAN LD_{50} (RANGE) IN MG/KG
Chukar[2]	25.9 (15.8 - 42.7)
House Sparrow	22.7 (14.6 - 35.1)
Pheasant	17.8 (9.33 - 34.0)
Canada Geese	12.0 (8.48 - 17.0)
Mallard[2]	5.94 (4.28 - 8.23)
Pigeon	4.63 (3.24 - 6.61)
Mourning Dove	2.68 (1.34 - 5.35)

[1]Tucker and Crabtree, 1970.
[2]90 percent technical formulation for Chukar and Mallard; 99 percent technical for other species.

Insecticides vary in acute toxicity within a given wildlife species (Table 2). Of the 12 insecticides listed in Table 2, phosdrin is the most toxic and DDT is the least toxic to 3 to 4 months-old pheasants. Although DDT exhibits low acute toxicity, it adversely affects pheasant chick survival (see beyond). None of these 12 insecticides should be used in pheasant habitats.

Table 2. LETHAL LEVELS OF 12 INSECTICIDES ON 3-4 MONTHS-OLD PHEASANTS.[1]

INSECTICIDE	FORMULATION	MEAN LD_{50} (RANGE) IN MG/KG
Abate	92 percent technical	31.5 (18.1 - 54.9)
Aldrin	95 percent technical	16.8 (---)
DDT	>99 percent technical	1,296 (745 - 2257)
Diazinon	89 percent technical	4.33 (3.02 - 6.22)
Endrin	97 percent technical	1.78 (1.12 - 2.83)
Guthion	2 pound/gallon	283 (200 - 400)
Meta-Sytox-R	50 percent technical	42.4 (30.6 - 58.8)
Phosdrin	100 percent analytical grade	1.37 (0.95 - 1.98)
TEPA	72.5 percent technical	25.2 (17.2 - 37.0)
TEPP	40 percent TEPP and 60 percent other ethyl phosphates	4.22 (2.93 - 6.09)
Thimet	98.8 percent technical	7.12 (4.94 - 10.3)
Toxaphene	90 percent technical	40.0 (20.0 - 80.0)

[1]Tucker and Crabtree, 1970.

Acute toxicity of an insecticide may vary with age classes within a species (Table 3). Parathion and zectran are more lethal to young mallards than are

dursban or toxaphene. Adult mallard mortality can be expected before duckling mortality with exposure to dursban. Six to eight days-old ducklings are more than twice as vulnerable to toxaphene as 3 to 5 months-old ducklings.

Table 3. LETHAL LEVELS OF FOUR INSECTICIDES ON DIFFERENT AGE CLASSES OF MALLARDS.[1]

INSECTICIDE	FORMULATION (PERCENT TECHNICAL)	AGE/BIRD	MEAN LD_{50} (RANGE) IN MG/KG
Dursban	99	17 Days	167 (78.3 - 357)
		Adults	70 - 80 (35.4 - 161)
Parathion	98.76	2-3 months	1.90 (1.37 - 2.64)
		3-4 months	2.13 (1.54 - 2.96)
Toxaphene	90	6-8 days	30.8 (23.3 - 40.6)
	100	3-5 months	70.7 (37.6 - 133)
Zectran	99[2]	17 days	4.2 (---)
		5-7 months	3.0 (---)

[1]Tucker and Crabtree (1970)
[2]Plus recrystallized three times.

Some wildlife species exhibit sex-linked sensitivity to a given insecticide (Table 4). Young pheasant cocks are twice as vulnerable to dursban as young hens. Landrin is slightly more toxic to male house sparrows than females.

Table 4. DIFFERENCES IN LETHAL LEVELS OF TWO INSECTICIDES ON SEX CLASSES OF BIRDS.[1]

INSECTICIDE	FORMULATION (PERCENT TECHNICAL)	SPECIES	SEX	MEAN LD_{50} (RANGE) IN MG/KG
Dursban	99	Pheasant	Female	17.7 (---)
			Male	8.41 (2.77 - 25.5)
Landrin	96	House Sparrow	Female	46.3 (37.4 - 57.3)
			Male	55.0 (38.5 - 78.6)

[1]Tucker and Crabtree, 1970.

Different formulations of a given insecticide vary in acute toxicity to a given species (Table 5). Guthion is four times more lethal to young pheasants in a 90 percent technical formulation than in a 2 pound/gallon formulation.

Sevin is virtually non-toxic in either the 95 percent technical or 4 pound/gallon formulations; there is greater sensitivity to the latter formulation.

Table 5. DIFFERENCES IN LETHAL LEVELS OF FORMULATIONS OF TWO INSECTICIDES ON 3-4 MONTHS-OLD PHEASANTS.[1]

INSECTICIDE	FORMULATION	MEAN LD_{50}	(RANGE) IN MG/KG
Guthion	90 percent technical	74.9	(59.5 - 94.3)
	2 pound/gallon	283	(200 - 400)
Sevin	95 percent technical	>2,000	(---)
	4 pound/gallon	707	(---)

[1]Tucker and Crabtree (1970).

Chronic Toxicities

Delayed Mortality

Illustrations of these effects were presented in "Acute vs. Chronic Toxicities". In addition, a Wyoming experiment (Post 1951), indicated adult pheasants did not die until about 20 days after lethal doses (200 mg/kg) of toxaphene were administered.

Prolonged Effects

Field studies have shown virtual elimination of wild turkeys after heptachlor application at field rates (DeWitt and George, 1960). Some turkey mortality was still occurring the second year after application.

Conversion of Applied Insecticides to More Toxic Chemicals

Aldrin converts to dieldrin, which has a higher acute oral toxicity (Rudd and Genelly 1956:54, 86), in the soil (from Rudd, 1964:166). Aldrin disappears rapidly from soil while dieldrin, whose formation peaks at about 2 months post-aldrin-spray, lingers for several years. Six to 12 times more dieldrin has been found in the soil than the aldrin quantity sprayed.

Combined Insecticide Use

Only limited evidence exists regarding the effects of applying two or more different insecticides simultaneously or within the same season. Lowest expected wildlife mortality should correspond to that from sole use of the most toxic insecticide. However, toxic effects of both insecticides could produce wildlife mortality greater than that expected from the single most toxic insecticide.

In a California mosquito control attempt, toxaphene was applied to an area previously treated with DDT and a DDT-dieldrin mixture (Rudd and Genelly, 1956:101). Domestic and wild ducks and geese died in the treated area. It was not known whether an overdose of one application or the combination of treatments resulted in the mortality. Regardless of the cause, these deaths could have been avoided.

Sublethal Effects

Viability or vigor can be reduced by exposure to sublethal quantities of insecticides. DeWitt (1956) demonstrated lowered viability of quail and pheasant chicks through adult hen diets containing sublethal levels of chlorinated hydrocarbon insecticides.

Insecticide use can disrupt normal animal behavior patterns. Field rodents appeared on the ground surface during poisoning campaigns, thus exposing themselves to predators (Craighead *In* Rudd, 1964:133). Both 3 and 10 days-old pheasant chicks displayed nervous disorders following methyl parathion spraying at 0.3 and 0.5 pound/acre (Christensen, 1971). This indicated probable mortality since wild birds under these handicaps could not fend for themselves and would be taken by predators. At 0.86 pound/acre methyl parathion, 60 percent of the chicks died; survivors demonstrated abnormal behavior similar to those exposed

to the lower rates.

DDT has received considerable attention due to the persistence of it and its metabolites in the environment. The acute oral LD_{50} of DDT for adult pheasants is 1,296 mg/kg (Tucker and Crabtree, 1970). Pheasant hens fed various sub-lethal levels of DDT in pre-breeding season diets passed DDT into their egg yolks. This did not result in lowered fertility or egg production, but chick viability was reduced within 2 weeks (Rudd and Genelly, 1956:85) and up to 47 percent of the chicks died within 6 weeks of hatching. Chick mortality rates were correlated with DDT levels in the parent's diets; mortality increased with an increase in DDT dietary levels.

DDE, the initial DDT metabolite, fed in concentrations of 10 and 40 ppm for 1 month prior to egg laying, severely impaired mallard reproductive success (Heath et al., 1969). Egg shells were also 13 percent thinner than normal which resulted in 25 percent of the eggs cracking. Hairline-cracked eggs hatched at about half the rate of intact eggs. No eggs with obvious breaks hatched. In uncracked eggs, embryo mortality during the final week of incubation ranged 30 to 50 percent higher than expected. Overall effect was the reduction of duckling production per hen by as much as 75 percent.

A five-summer study in the Flathead Lake area projected osprey population declines at the rate of 3 to 4 percent per year (MacCarter, D. L., 1972). Thin egg shells coincidental with high DDT-levels were found to be a major contributing factor.

Toxaphene significantly reduced pheasant hatching and induced significant chick mortality during the first 2 weeks after hatching (Genelly and Rudd, 1956).

Dieldrin fed to pheasants at 25 and 50 ppm resulted in reduced egg production and poor chick survival (Rudd and Genelly, 1956:87).

Transferred Effects

Two studies on southeastern Montana rangelands demonstrated resident bird population declines following insecticide application with no mortality observed. Sevin, applied once at 1 pound/acre for grasshopper control, resulted in no detected vertebrate deaths yet bird counts were reduced 83 percent within 2 weeks of application (Finley, 1960). Eng (1952) observed no mortality of resident birds following chlordane-baiting or aldrin-spraying. Slight reductions in bird populations following both treatments led him to conclude that a 50 percent reduction in grasshopper numbers was sufficient to cause insectivorous birds to leave during the nesting season.

In such cases, subtle, nonlethal effects on resident bird populations might include:

1. Annual reduction in local bird populations through interrupted nesting or brooding;
2. Abnormal stress imposed on displaced birds moving to less familiar areas;
3. Additional breeding season stress on encroached bird populations;
4. Seasonal reduction in numbers of natural, insectivorous predators on the treated area.

These effects may be short or long term depending on insecticides used, frequency of application, and application rates.

Side Effects

Widespread aphid outbreaks in grain fields were associated with selective treatment with 2, 4-D (Adams *In* Rudd, 1964:135). This plant growth hormone reduced the number of predaceous ladybird larvae and adults. Subsequent insecticide use to control aphids could be expected. Nine of the 14 aphid-control

insecticides recommended by Montana's Cooperative Extension Service (1969) are acutely toxic to various wildlife species. Four of the remaining insecticides require additional study and only one, malathion, shows no currently known adverse affects to terrestial game animals.

Substitution

Reduction of a prey species can result in predators shifting to other prey sources. The use of certain insecticides, or rodenticides, to control rodents could result in predators concentrating their hunting efforts on game species. Game birds in habitats having low security levels could be severely reduced in number.

Competition

Grasshopper-livestock forage competition is routinely observed in Montana. Grasshopper control chemicals recommended for Montana include aldrin, phosdrin, toxaphene and malathion (Cooperative Extension Service, 1969). The aldrin-dieldrin conversion was discussed previously. Dieldrin is highly toxic to sharp-tailed grouse (LD_{50} of 6.9 mg/kg, Litchfield and Wilcoxon *In* McEwen and Brown, 1966). Abnormal sharptail behavior, leading to disrupted breeding activities and above normal vulnerability to predators, after dieldrin exposure was demonstrated in Montana (McEwen and Brown, 1966). Phosdrin is highly toxic to sharptails, pheasants and mallards (LD_{50}'s of 0.75-1.50, 1.37 and 4.63 mg/kg, respectively) (Tucker and Crabtree, 1970:93). Toxaphene is highly toxic to ducks, geese, pheasants, sharptails and many non-game birds (Harris, 1951; Tucker and Crabtree, 1970; Post *In* Rudd and Genelly, 1956:100). While malathion appears currently acceptable for grasshopper control, it is quite toxic to fish and should not be used near streams, lakes or ponds.

Eight grasshopper-insecticides were range-tested in eight western states, including Montana. Because of their high acute toxicity to wildlife diazinon, fenitrothion and toxaphene were not recommended for range grasshopper control (McEwen, et al., 1972). Guthion and mobam applications did not result in direct wildlife mortality but post-spray bird populations were lower than pre-spray populations; further investigation of different application rates was recommended. Malathion (9.7 ounces/acre), carbaryl or sevin (up to 1 pound/acre) and BAY 77488 (2.5 ounces/acre) appeared to be the most promising chemical controls.

The long term solution to grasshopper-livestock forage competition is proper range management. In Oklahoma, grasshoppers were eight times as abundant on overgrazed lands as on conservatively grazed lands (Weese *In* Rudd 1964:234). In Kansas, Smith (1958) found grasshoppers were more abundant on heavily grazed lands than on nearby ungrazed land. A study in British Columbia 50 years ago concluded: "Judicious management of cattle within selected grazing limits is the keynote of success in grasshopper control on the range " (Treherne and Bucknell *In* Rudd 1964:234). Drought conditions may continue to favor periodic grasshopper outbreaks even on well managed ranges. Restricted use of relatively "safe" insecticides can be justified in such cases. Continued use of insecticides to "bail out" the poor range manager cannot be endorsed.

Carriers

Problems occasionally arise from the type of insecticide-carrier employed. Pheasant eggs sprayed (on one side to simulate field application) with Number 1 diesel fuel resulted in complete embryo mortality (Kopischke, no date). This study concluded that oil-base carriers should not be used in areas where birds are nesting.

Recommendations

To minimize the effects of insecticides on wildlife two concepts must be recognized:

1. Insecticides are an environmental insult; they disrupt, in some manner, the natural processes of any given ecosystem;
2. Continued or increased ecosystem disruption can lead to a simplified, unnatural and unstable environment on which humans as well as wildlife depend for existence.

Once these concepts are accepted it follows that insecticide use must be curtailed if their effects are to be minimized. The most important decision the land manager must make is whether the use of an insecticide is absolutely necessary. Changes in land management philosophy, which must precede changes in land use practices, could minimize the number of these decisions he may face in the future.

When insecticide use is deemed absolutely necessary:

1. Insecticides causing the least environmental damage should be used;
2. Application rates should be strictly adhered to;
3. Insecticides should be applied only to known insect problem sites;
4. Surplus insecticide should not be applied on adjacent areas merely for the sake of disposal, they should be safely stored or disposed of in a manner which will not contaminate the environment;
5. Residues resulting from cleaning spray equipment contain active insecticide and should be deposited in a manner which will cause the least environmental contamination.

Insecticide application decisions should reflect the full consideration of human health and environmental impacts as well as economic considerations.

The Montana Fish and Game Department is willing to assist in these decisions. Insecticides which have shown adverse effects to wildlife and which are not recommended by the Montana Fish and Game Department for public use are listed in Appendix II.

LITERATURE CITED

Christensen, G. C. 1971. The effects of parathion upon pheasant populations in Smith and Mason Valleys, Nevada. Proc. 51st Ann. Conf. Western and Midwest Fish and Game Comms. 17 pp.

Cooperative Extension Service. 1969. Materials for insect control in Montana, 1969. Montana State University (Bozeman), Leaflet 101 Revised. 29 pp.

Crabtree, D. G. 1965. Wildlife studies, Denver Wildlife Research Center. Pp. 31-48. *In* Effects of pesticides on fish and wildlife: 1964 research findings of the Fish and Wildlife Service. U. S. Dept. Interior, Fish and Wildl. Serv. Circ. 226. 77 pp.

Davis, C. V. 1963. Birds of Montana. Montana Wildlife. Aug.: 23-27.

DeWitt, J. B. 1956. Chronic toxicity to quail and pheasants of some chlorinated insecticides. J. Agric. and Food Chem., 4 (10):863-866.

_____ and J. L. George. 1960. Bureau of Sport Fisheries and Wildlife Pesticide-Wildlife Review: 1959. U. S. Dept. Interior, Fish and Wildl. Circ. 84. 36 pp.

_____, W. H. Stickel, and P. F. Springer. 1963. Wildlife studies, Patuxent Wildlife Research Center. Pp. 74-96. *In* Pesticide-Wildlife Studies: a review of Fish and Wildlife Service investigations during 1961 and 1962. U. S. Dept. Interior, Fish and Wildl. Serv. Circ. 167. 109 pp.

Eng, R. L. 1952. A two-summer study of the effects on bird populations of chlordane bait and aldrin spray as used for grasshopper control. J. Wildl. Mgmt., 16(3):326-337.

Finley, R. B., Jr. 1960. Direct and indirect effects of some insecticides on western wildlife. Proc. Ann. Conf. W. Assoc. Game and Fish Comms., 40:121-129.

Genelly, R. E. and R. L. Rudd. 1956. Effects of DDT, toxaphene and dieldrin on pheasant reproduction. Auk, 73(4):529-539.

Harris, B. K. 1951. The effects of toxaphene poisoned grasshoppers upon pheasant chicks. North Dakota Outdoors, 13(8):12.

Heath, R. G., J. W. Spann, and J. F. Kreitzer. 1969. Marked DDE impairment of mallard reproduction in controlled studies. Nature, 224:47-48.

Kopischke, E. E. No date. Effect of 2, 4-D and diesel fuel on egg hatchability. Minnesota Fish and Game Department, Game Res. Spec. Rept. 4 pp.

MacCarter, D. L. 1972. Reproductive performance and population trends of ospreys at Flathead Lake, Montana. M. S. thesis, Humboldt State College (Arcata, California). 80 pp.

MacCarter, D. S. 1972. Food habits of ospreys at Flathead Lake, Montana. M. S. Thesis, Humboldt State College (Arcata, California). 80 pp.

McEwen, L. C. and R. L. Brown. 1966. Acute toxicity of dieldrin and malathion to wild sharp-tailed grouse. J. Wildl. Mgmt., 30(3):604-611.

_____, E. E. Knittle and M. L. Richmond. 1972. Wildlife effects from grasshopper insecticides sprayed on short-grass range. J. Range Mgmt., 25(3):188-194.

Mussehl, T. W. and R. B. Finley, Jr. 1967. Residues of DDT in forest grouse following spruce budworm spraying. J. Wildl. Mgmt., 31(2):270-287.

_____ and F. W. Howell (Editors). 1971. Game management in Montana. Montana Fish and Game Department, Game Management Division. 238 pp.

_____ and P. Schladweiler. 1969. Forest grouse and experimental spruce budworm insecticide studies. Montana Fish and Game Department, Tech. Bull. No. 4. 53 pp.

Pillmore, R. E. and R. B. Finley, Jr. 1963. Insecticide residues in game animals. Trans. No. Amer. Wildl. and Nat. Res. Conf., 28:409-422.

Post, G. 1951. Effects of toxaphene and chlordane on certain game birds. J. Wildl. Mgmt., 15(4):381-386.

Rudd, R. L. 1964. Pesticides and the living landscape. University of Wisconsin Press, Madison. 320 pp.

_____ and R. E. Genelly. 1956. Pesticides: their use and toxicity in relation to wildlife. California Fish and Game Department, Game Management Branch, Game Bull. No. 7. 209 pp.

Seidensticker, J. C., IV. 1968. Response of juvenile raptors to DDT in the diet. J. Amer. Vet. Med. Assoc., 155(7):1,044-1,045.

Smith, C. L., Acting Assistant Director, Pesticides Office, Environmental Protection Agency (Washington, D. C.). Personal Communication. March 15, 1973.

Smith, R. E. 1958. Natural history of the prairie dog in Kansas. University Kansas, Mus. Nat. Hist., Misc. Publ. 16. 36 pp.

Tucker, R. K. and D. G. Crabtree. 1970. Handbook of toxicity of pesticides to wildlife. U. S. Dept. Interior, Bureau of Sport Fisheries and Wildlife, Denver Wildl. Res. Center, Resource Publ. No. 84. 131 pp.

Wright, P. 1959. Montana mammals. Montana Wildlife.

APPENDIX I

In May, 1964 the Montana Fish and Game Commission adopted the following Policy on Pesticides:

"In considering all the disturbing facets involved in massive spraying or dusting of pesticides, the Fish and Game Commission has adopted the following policy -- To:

1. Oppose mass aerial spraying of public lands in Montana with any of the chlorinated hydrocarbon chemicals.
2. Protest the mass aerial application of other pesticides, including herbicides, on public lands in Montana until the users conduct intensive studies on limited areas to determine the chemicals' effectiveness in controlling the target organisms and also the effect on other fauna and flora and to inform the public of their findings.
3. Request that federal agencies re-evaluate their policies and concept of multiple-use of public lands in relation to mass use of pesticides, especially weedicides (herbicides).
4. Make information relative to the use and total effects of pesticides, including herbicides, available to the public."

The applicability of this policy has remained in effect for 9 years.

APPENDIX II

Insecticides recommended for use in Montana by the Cooperative Extension Service (1969) and which are not recommended by the Montana Fish and Game Department[1] for public use:

Aldrin	Endrin	Systox
Chlordane	Meta-Systox R	Thimet
Diazinon	Parathion	Thiodan
DDT	Phosdrin	Toxaphene
Di-Syston	Phosphamidon	

Insecticides not included in Cooperative Extension Service (1969) recommendations which produce high acute toxicities in terrestrial wildlife and which are not recommended by the Montana Fish and Game Department[1] for public use:

Azodrin	Dieldrin	GC 6506
BAY 37289	Dursban	Lannate
Baygon	EPN	Methyl Parathion
Baytex	Famophos	Telodrin
Bidrin	Furadan	TEPA
DDVP		TEPP

[1]Subject to review, change and approval by the Montana Fish and Game Commission.

Exclusion of an insecticide from these lists does not purport endorsement by the Montana Fish and Game Commission.